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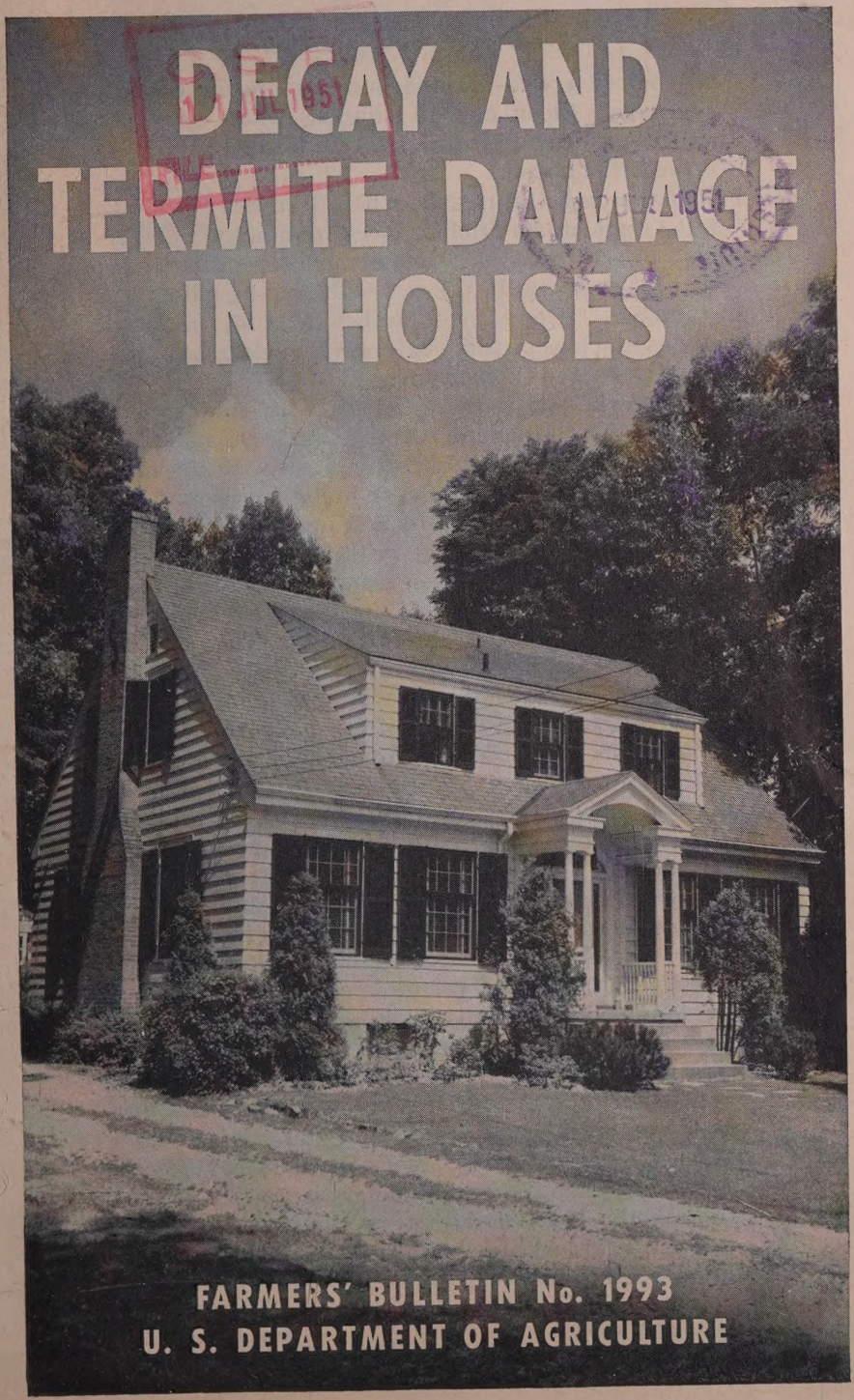
DECAY AND TERMITE DAMAGE IN HOUSES



FARMERS' BULLETIN No. 1993
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Points for Special Attention

Site. Select a well-drained building site or provide drainage. Clear out all stumps, wood or paper debris, grade stakes, and concrete forms from under or near the house.

Foundation cap. In regions where termites are active put a tight cap on brick or block foundations, preferably of reinforced concrete or noncorrodible metal; seal all openings in the cap with coal-tar pitch.

Dry lumber. If any green lumber must be used let it dry as much as possible before it is enclosed. Avoid heavily stained lumber.

Soil contacts. Allow no wood to be in contact with the soil in permanent construction. Do not place earth-filled porches in direct contact with the main building without concrete or metal barriers.

Masonry contacts. Protect by a damp-proof layer any wood that is in contact with concrete near the ground. Provide air space around the ends of joists let into masonry walls. If the joists are below the outside soil level, moistureproof the outer face of the wall.

Crawl space. Where there is no basement, leave a crawl space with at least an 18-inch clearance under wood joists and girders. Provide openings on opposite sides for cross ventilation, or lay roll roofing on the soil. See section on ventilation.

Walls and attics. For sheathing paper, use only "breathing," or vapor-permeable, types. Install vapor barriers near warm face of insulated walls and ceilings. Provide cross ventilation in attics.

Rain water. Design exterior joints to allow the least possible entrance and retention of rain water. Roof overhang with gutters is desirable. Keep roofs tight and don't let leaves clog gutters and downspouts.

Inspection. Preferably in winter or early spring inspect roof sheathing at north eaves, and sills, joists, and the foundation wall inside and out. If you find termite tubes or damage, block the entry routes with mortar or pitch if possible; otherwise, apply poisons to the soil. If you find decay or visible moisture that is not due to leaks, dry out by drainage, ventilation, and/or soil cover.

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DECAY AND TERMITE DAMAGE IN HOUSES

Prepared by the DIVISION OF FOREST PATHOLOGY, *Bureau of Plant Industry, Soils, and Agricultural Engineering*, and the DIVISION OF FOREST INSECT INVESTIGATIONS, *Bureau of Entomology and Plant Quarantine, Agricultural Research Administration*

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When wood is properly used, it is dependable building material. Termites and decay cause little damage to houses that are well built and maintained. Prevention is cheap; cure is sometimes expensive. Most damage is due to readily avoidable errors.

CAUSES OF DAMAGE

Termites (fig. 1) are the most destructive of the insects that attack wood in houses. They eat the interior of the wood (fig. 2) and may cause much damage before they are detected. The kinds that cause most of the damage in this country must have constant access to moist soil, with which they can connect by tubes (fig. 3). They are relatively unimportant in the northernmost States, but precautions must be taken against them in most parts of the country.

Wood decay is caused by fungi, which are plants consisting of microscopic threads. These threads become visible to the naked eye when many of them occur together, as in figure 4, or when they produce the fruiting bodies from which their spores are distributed (fig. 5). Some fungi merely discolor the wood, but the decay fungi weaken or

destroy the fiber. They cannot work in dry wood. There is no such thing as "dry rot"; decayed wood is often dry after it has rotted, but not while the decay is taking place. There are two species of fungi that can spread from moist soil or wood into dry wood. They do this by taking their water with them.[1] These two cause very great damage to occasional buildings, but fortunately most fungi cannot

Figure 1.—*A* and *B*, Worker termites; *C*, winged termite; *D*, winged ant. The wasp waist of the ant and the long wings of the termite are distinguishing characteristics. *A*, *C*, and *D*, Greatly enlarged; *B*, natural size.

[1] Richards, C. A. Decay in Buildings. American Wood-Preservers' Assoc. Proc. (1933) 29: 389-398, illus. 1933.

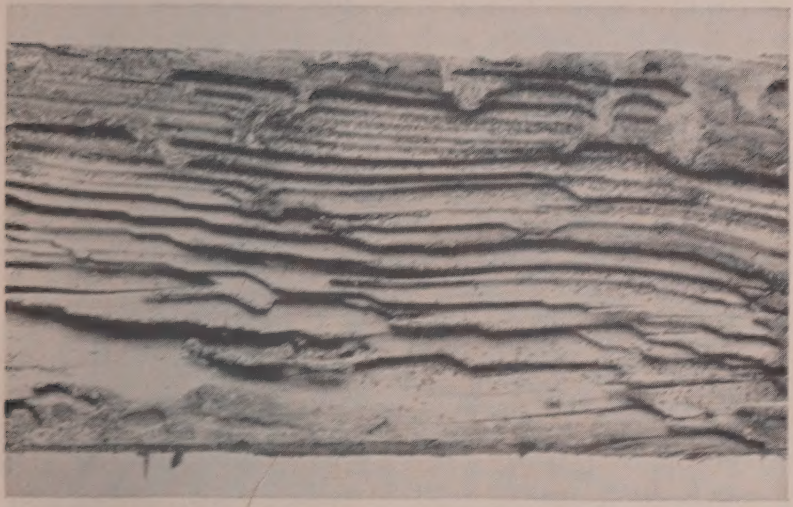

Figure 2.—Wood honeycombed by termites. Exterior surface has been removed to reveal the extensive tunneling within, along the grain. The wood remaining between the tunnels is firm, except in cases in which wood-rotting fungi have also been active.

Figure 3.—Shelter tubes made by termites over concrete foundation wall in poorly ventilated basementless area beneath a building. Many tubes are being extended downward from the damaged sill to the ground to reach moisture.

conduct moisture in this way. Decay is least important in the driest parts of the country.

Wood damaged by termites can be easily distinguished from decayed wood. Termites honeycomb the wood with definite tunnels; these are

separated by thin partitions of sound, firm wood (fig. 2). The decay fungi soften the wood and in the final stages cause it to shrink and crack or crumble (fig. 4). None of the fungi cause continuous clear-cut tunnels or galleries such as are produced by termite feeding. The fungi and the termites, of course, sometimes work in the same wood. In such cases the partitions between the termite galleries are softened.

Serious damage is most often due to the following errors in construction or maintenance:

1. Undrained soil and insufficient ventilation under basementless houses.
2. Wood or paper debris left on or in soil under houses.
3. Wood parts of the house in direct contact with the soil, especially at dirt-filled porches.
4. Wood parts embedded in masonry near the ground.
5. Masonry foundation without a tight cap.
6. Sheathing paper that is not sufficiently permeable to moisture vapor.
7. Lack of rain gutters, and roof without overhang.
8. Unventilated attics.
9. Roof leaks, leaks around shower-bathtub combinations, and frequent overflow of refrigerator pan, or excess water used in washing floors.

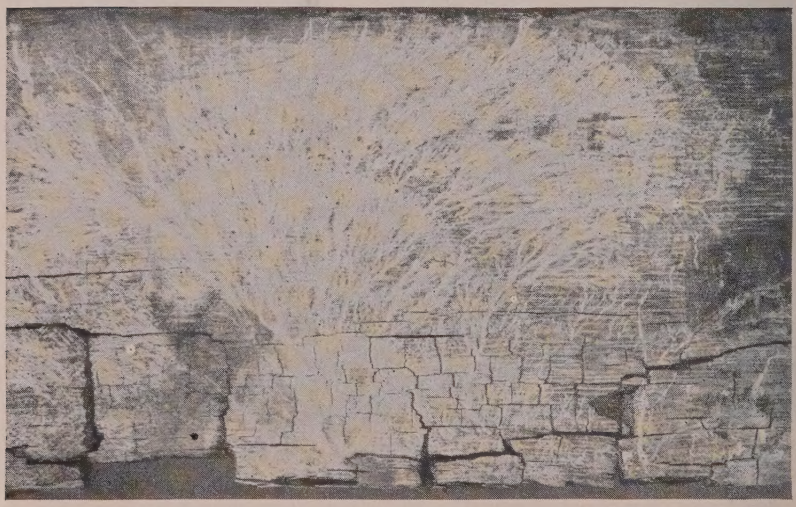

Figure 4.—A decay fungus and its effect on wood. The tiny threads of which fungi mainly consist grow within the wood and can be seen there only with a microscope. Where the air is very moist they may develop on the surface in sufficient quantity to be visible. The upper part of the wood in this specimen is softened and weakened, and the lower edge cracked and nearly disintegrated, but fungi make no definite galleries such as those cut by termites.

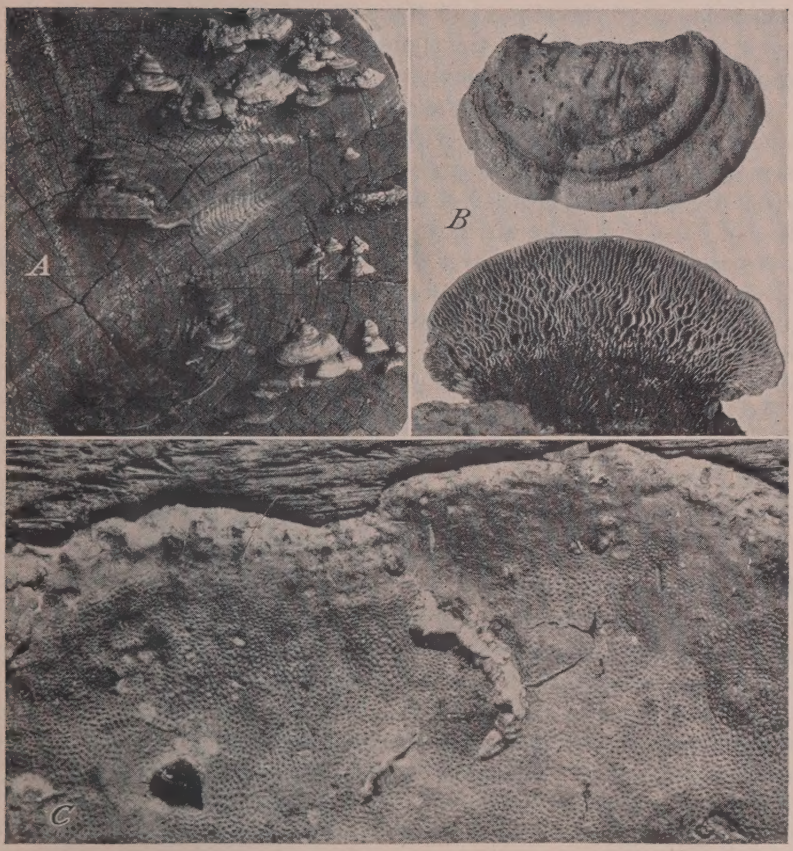

Figure 5.—Fruiting bodies of different types of wood-rotting fungi. *A,* One of the bracket fungi common on softwoods exposed to rain. *B,* Upper and lower surfaces of a gill fungus. *C,* The crustlike fruiting body of a pore fungus. The microscopic spores by which these fungi are spread to new locations are produced on the gills or pore surfaces on the lower sides of the fruiting bodies.

GENERAL SAFEGUARDS

The basic requirements for protection are simple—keep soil-inhabiting termites and decay fungi from entering the lower part of the structure. To prevent decay, use dry wood as far as practicable and build in a way that will keep it dry most of the time.

Use of Dry Lumber

Only seasoned lumber should be used. It has better ultimate nail-holding capacity than wood nailed while green, shrinks and warps less, and is safer from decay than green wood. Decay can occur only

when the wood contains more than 20 percent moisture.[2] Air-dry wood is regularly below this point. During construction, lumber should be stored off the ground and protected from rain.

If only green material can be obtained, it should be open-piled on the job to let it dry as much as possible before it is used. The piles should be supported off the ground, the layers separated from each other by narrow strips of 1-inch dry lumber. The boards in each layer should be spaced to let air move up or down between them. If the piles cannot be put under cover they should slope toward one end and the boards in the top layer should overlap and extend out at the front and back to keep rain off the boards beneath. Green lumber requires 60 days or more for thorough seasoning, but a shorter period will do much to decrease the chance of decay.

Wood that is heavily discolored by blue-stain fungi also is likely to contain decay fungi; these may continue to spread as long as the wood remains moist. If such wood must be used, it is particularly necessary to have it dry before it is enclosed. Even well-seasoned wood becomes liable to decay if it takes up too much moisture.

Protection Against Rain

Roofs with considerable overhang, both at eaves and gable ends, give more protection to the rest of the house than those with narrow overhang. In regions with heavy snow, the lower courses of shingles should be flashed to keep melting snow from working into the walls. Gutters and downspouts are particularly desirable for houses without overhanging eaves. Horizontal wood surfaces or projections, including windows and doors, should be flashed with a noncorroding metal.

In general, architectural frills or novel forms of construction should be studied carefully to determine whether they will provide entrance points or pockets in which moisture will remain long enough to let decay get started. Wood takes water most readily through exposed ends, as in joints.

Naturally Decay-Resistant Wood

The sapwood of all species of trees is susceptible to decay. Heartwood of most species, usually recognizable by its redder or darker color, is more durable. In Douglas-fir, southern pine, and white oak the heartwood is classed as moderately resistant. In tidewater red cypress and in redwood it is highly resistant both to decay and to termites and can even be used in contact with soil in semipermanent construction if there is no sapwood attached. However, it is not equivalent to wood fully impregnated with an effective preservative. Cedars are generally resistant to decay but not to termites. The

[2] More complete information is available in U. S. Dept. Agr. Tech. Bul. 174, The Air Seasoning of Wood.

highly durable hardwoods, as black walnut, catalpa, Osage-orange, and the better varieties of black locust, are too hard or too scarce for general use in construction. Heartwood of resistant species is increasingly difficult to obtain and cannot be the principal reliance for safety in most house construction. Where preservative-treated lumber is not available for use, it is good practice to pick out the pieces containing the most heartwood for use in sills, porches, outside steps, and the lowest siding boards.

Paint and Preservatives

Paint is not a preservative. In many cases it may prevent decay by protecting wood from intermittent wetting, especially if applied to ends and edges as well as exposed faces and so maintained as to allow the fewest possible cracks at joints. In some other cases, as for example when applied to wood that is not seasoned, it may favor decay by hindering further drying. Painting is not a substitute for good construction details and maintenance. In warm moist climates or in rooms with very moist air, molds may develop on the paint or on dirt or small insects that adhere to it, and make it unsightly. Paints having low oil content and much zinc oxide are safest in this respect. On the Gulf coast, where mildew is most common, fungicides to protect paint can be obtained from paint stores, with instructions for use. Many of the fungicides are highly poisonous. Read caution on page 23 before attempting to use them.

Where wood is protected from wetting, treatment with preservatives is not necessary. To prevent decay, the use of treated wood is advised for any members that are not likely to be properly protected against excessive moisture, unless heartwood of a highly resistant species is available. Stringers in or on concrete, and porches, sills, and joists, are the members for which thorough preservative treatment could be most easily justified.

To be fully protected, wood must be deeply impregnated with the preservative. This can be done best by treatment under pressure. Less efficient but often adequate treatment can be given by heating wood and then soaking it in a cold preservative, or in the case of thin or short pieces, by cold soaking alone. Wood that is cut and fitted after treatment should be given a heavy brush treatment on the cut surfaces.[3]

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[3] More complete information on wood preservation is contained in the following reports, which may be obtained from Forest Products Laboratory, Madison, Wis.: R149, Wood Preservatives; R154, Methods of Applying Wood Preservatives; R621, Preservation of Timber by the Steeping Process; R919, Preservative Treatment of Window Sash and Other Millwork; R982, Making Log Cabins Endure; R1092, The Treatment of Sawdust Insulation for Protection Against Decay, Insects, Animals, and Fire. Additional information is available in U. S. Dept. Agr. Circular 683, Effectiveness of Wood Preservatives in Preventing Attack by Termites.

Wood can be given some protection from decay by more superficial treatments with preservatives, but chemicals added by brushing or dipping penetrate the wood surprisingly little, except in some species, through exposed ends. Such treatment is not advised for wood exposed to the most severe conditions, but can considerably increase the service life of wood that is to be exposed to rain but is not in contact with the ground. Its effectiveness can be increased by painting the wood after treatment. A dip treatment is also suggested for the ends of joists and siding in moist conditions.

It is even possible in some situations to give a somewhat effective treatment to wood already in place in a building. Ordinary brushing or spraying does little; but in some places a preservative solution can be fed to a wood surface by a wick or a dripping device so slowly that the wood absorbs the preservative as fast as it comes. In this way treatment can be continued for a week or more and pine sapwood sometimes will take up several pounds of preservative per cubic foot of wood.

However, there are difficulties with this type of treatment. The mineral spirits in which most ready-to-use preservatives are dissolved would evaporate too quickly. Kerosene or a less volatile solvent, such as diesel fuel, therefore should be used. The parts of a building most likely to decay are not easily reached. Wood that has a good paint coat would not take treatment, and on the other hand, a surface thoroughly treated with one of the heavier solvents would not take paint for some months. Unless done at a time when the wood is moderately dry, penetration by an oil solution will be poor and no method has been worked out for applying water-soluble preservatives in this way. It is much easier and better to treat the wood before it goes into construction; and treated or untreated, it should still be guarded against excessive moisture.

HOW TO SAFEGUARD WOODWORK CLOSE TO THE GROUND

The older type of house built well above the ground is the safest, but most people prefer the modern low type of architecture. This, together with the unavoidable use of sapwood from second-growth timber, has operated to increase the decay hazard. Sills, joists, floors, and lower walls may suffer heavily from termites (fig. 6) or from decay fungi that come up from the soil. Their decay may also be favored by moisture that comes from the soil as vapor and condenses on the cold sills or the outer ends of the joists when the outdoor temperature is low (fig. 7). The following precautions are advised.

Drainage

Moist building sites should be well drained. The soil surface should slope away from the house, and downspouts should discharge into

Figure 6.—Termites have destroyed the sill and part of the studding of this building. The brick foundation should have had a tight cap. Brick work between the studding is undesirable.

Figure 7.—Moisture condensation on joists of a basementless house on a moist site. This occurs in cold weather and would in the end lead to decay. It can be avoided by ventilation or, at low cost, by covering the soil below with roll roofing.

approved drains or into masonry gutters or splash blocks that lead the water several feet away from the house. Dense shrubbery or vines planted too close to the house can interfere with drainage and air movement and thus promote fungus growth and termite activity. Termites sometimes reach the exterior woodwork by tunneling through dead parts of woody vines.

Contact of Wood With Soil

Allow no wood to be in connection with the soil unless it is thoroughly impregnated with a suitable wood preservative. For the greatest safety to permanent buildings, there should be no wood-soil contact of any kind. Remove all wood forms, grading stakes, and spreader sticks from concrete work under houses, porches, or steps. Wood skirting or lattice should be kept off the soil by putting a low concrete base under it, or in the case of lattice by suspending it above the soil with a clearance of at least 2 inches. This also applies to wood housings around plumbing and water pipes underneath houses. Mineral insulation is preferable to wood housing around pipes cold enough to "sweat."

Dirt fills under concrete or masonry porch floors frequently provide points of entry for both termites and decay fungi (fig. 8, *A*). Leaving scraps of wood in the soil about the foundation is one of the surest methods of inviting termites into a building. Wood debris in the soil, even in very small quantities, enables termites to develop colonies that may later infest the building. If the dirt under the porch comes up to the level of the sills or joists of the house, these can be protected from contact with the soil by noncorrosive metal flashing (as shown in fig. 8, *B*) or by building the porch as an independent unit separated from the house at all points by an air space 2 or 3 inches in width and covered at the top. A safe and perhaps easier method is to abandon the use of the dangerous dirt fill and pour a reinforced concrete porch slab. If this is done, a sufficient opening must be left to allow removal of wood forms and to serve as a permanent access for termite inspection. Where this impracticable, sheet-metal forms are suggested.

Contact of Wood With Concrete or Masonry

Embedding wood in concrete near the soil is an invitation both to termites and to decay (fig. 9). This is especially true of stakes left projecting through the concrete. Any wood placed against concrete or masonry that is in direct contact with soil should be protected from moisture by a vapor barrier between the wood and the concrete. The vapor barrier could be undiluted hot coal tar, asphalt roll roofing, corrosion-resisting metal, or at least asphalt paint.

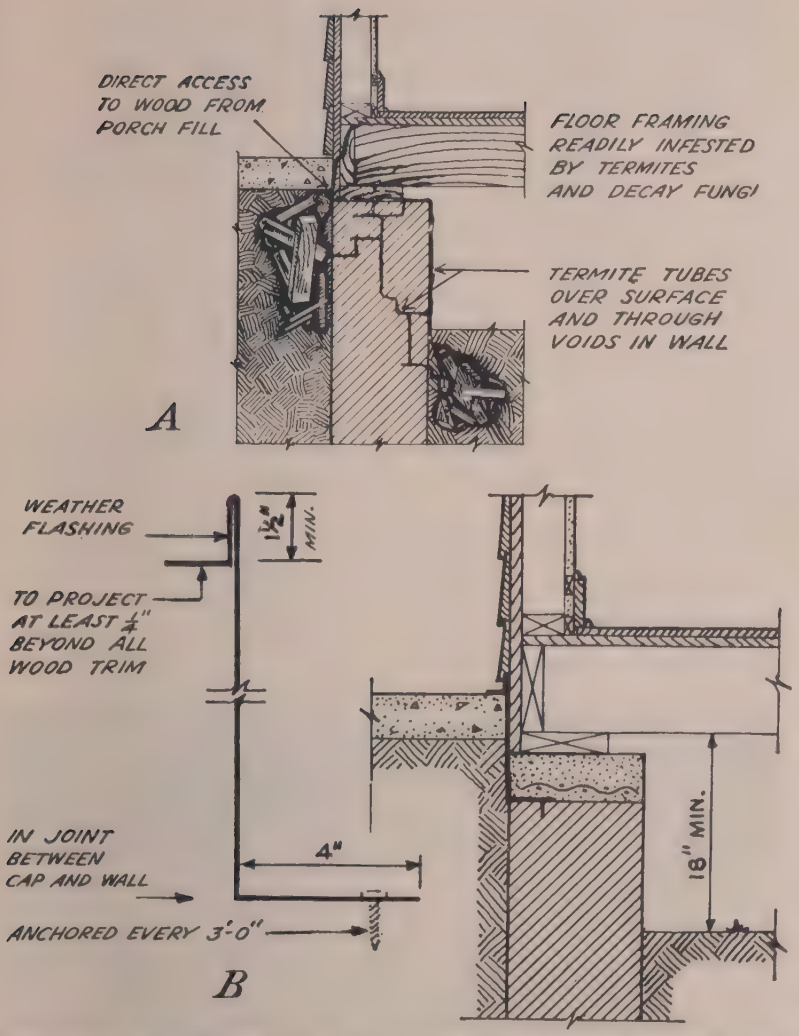
DIRECT ACCESS TO WOOD FROM PORCH FILL
FLOOR FRAMING READILY INFESTED BY TERMITES AND DECAY FUNGI
TERMITE TUBES OVER SURFACE AND THROUGH VOIDS IN WALL
A
WEATHER FLASHING
1½" MIN.
TO PROJECT AT LEAST ¼" BEYOND ALL WOOD TRIM
IN JOINT BETWEEN CAP AND WALL
4"
ANCHORED EVERY 3'-0"
18" MIN.
B

Figure 8.—Dirt-filled porches: *A*, Bad practice—an infestation originating in debris may spread through hidden points of access from porch fill or up through voids or cracks in a unit-type wall. Infestations in the debris encourage the construction of shelter tubes on a wall in enclosed or partially excavated areas. The most destructive of the decay fungi also are likely to enter the house from soil contacts of the kind shown here. *B*, Good practice—metal apron inserted between concrete slab and woodwork, anchored to unit-type foundation, and capped with reinforced concrete. The apron serves as a weather flashing as well as a barrier against termites and decay. The flashing should be continued 3 inches beyond the slab at both ends of the porch. If a termite shield is installed over the whole foundation the flashing can be made continuous with it and placed over the wall instead of under a cap.

Wood posts resting on concrete floors should be protected from floor moisture by placing them on raised concrete bases (fig. 10).[4]

If a wood floor is laid on a concrete slab there should be a dampproof membrane, preferably in the upper part of the slab, or the upper surface of the slab should be thoroughly coated with tar or asphalt; where termites are frequent, hot coal-tar pitch mopped on builder's felt is preferable (fig. 11). Even with such protection it is safest to have stringers and the subfloor impregnated with a preservative. Linoleum or other vapor-barrier coverings on wood floors increase the chance of trouble where moisture rises through the slab from the ground beneath. Vapor barriers are beneficial if placed where they will keep moisture from getting into the wood, but can be harmful if they keep moisture from getting out.

Expansion joints between concrete floors and foundation walls, or at openings through which piping penetrates floors or walls, should be sealed with coal-tar pitch or coal-tar plastic cement to prevent termite entry.

Around houses with wood floors and masonry walls the outside soil grade should be kept below the level of the joists at least unless the wall is thoroughly moistureproofed. Joists or girders framed into masonry should have a ½-inch air space on each side and at the ends, or the ends should be dampproofed.

Figure 9.—Damage to untreated sleepers embedded in concrete flooring.

[4] Figures 10, 11, 15, 16, and 17 are from Forest Products Laboratory Technical Note 242, which shows additional illustrations of good and poor practices.

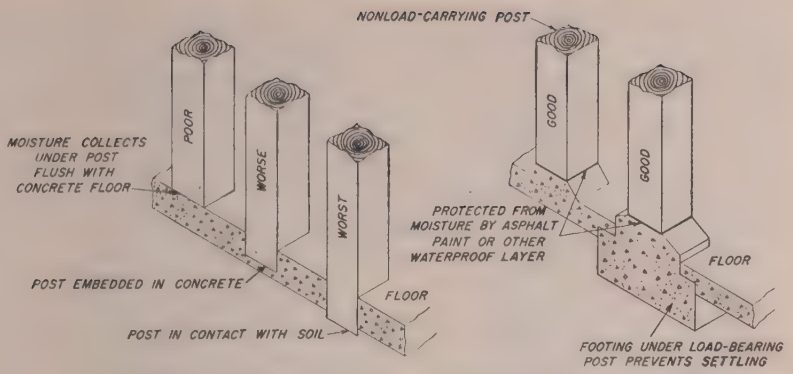

Figure 10.—Wood posts on concrete basement floors.

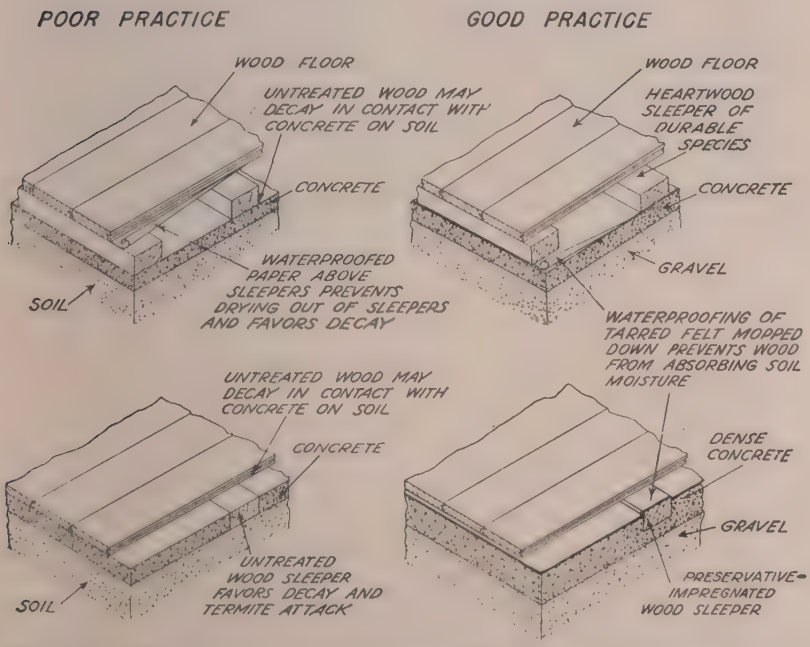
POOR PRACTICE
GOOD PRACTICE
WOOD FLOOR
UNTREATED WOOD MAY DECAY IN CONTACT WITH CONCRETE ON SOIL
CONCRETE
WATERPROOFED PAPER ABOVE SLEEPERS PREVENTS DRYING OUT OF SLEEPERS AND FAVORS DECAY
SOIL
WOOD FLOOR
HEARTWOOD SLEEPER OF DURABLE SPECIES
CONCRETE
GRAVEL
WATERPROOFING OF TARRED FELT MOPPED DOWN PREVENTS WOOD FROM ABSORBING SOIL MOISTURE
UNTREATED WOOD MAY DECAY IN CONTACT WITH CONCRETE ON SOIL
CONCRETE
UNTREATED WOOD SLEEPER FAVORS DECAY AND TERMITE ATTACK
SOIL
DENSE CONCRETE
GRAVEL
PRESERVATIVE-IMPREGNATED WOOD SLEEPER

Figure 11.—Wood floors on concrete slabs. Waterproofing membranes may be placed in or under the slab instead of on it.

Ventilation [5]

Under houses without cemented basements, the soil supplies moisture vapor to the air. In winter this may condense on the cold sills and joist ends, just as the moisture of the air condenses on a glass of

[5] For fuller information see publication entitled "Condensation Control in Dwelling Construction" by the Forest Products Laboratory, U. S. Department of Agriculture, and the Housing and Home Finance Agency. For sale by the Superintendent of Documents, Government Printing Office, 20 cents.

ice water. This "sweating" (fig. 7) if continued wets the wood to the point at which the decay fungi can attack it. Because of this, and also to make inspections possible, leave a crawl space under the house with at least 18-inch clearance under all wood members. There are two ways to prevent condensation.

One way is to provide cross ventilation for all parts of this crawl space by openings in the foundations or skirting on opposite sides of the building, best near the corners. For the greatest safety these vents should have a total area equal to 2 square feet for each 100 linear feet of wall, plus $\frac{1}{3}$ square foot for each 100 square feet of crawl-space area. For small houses, the simpler formula of 1 square foot for each 25 linear feet of wall is considered sufficient. If the vents have grills in them, only the area of the actual openings should be counted. If the vents have louvers, they should be twice as large, or if both louvers and 16-mesh screen, 3 times as large as the formula calls for. Insect screen commonly becomes clogged with paint, dirt, and cobwebs; it is better to use $\frac{1}{4}$-inch mesh, which keeps out rodents.

Sufficient ventilating effect can of course be had with smaller vents, if aided by an exhaust fan or by a stack running from the crawl space up through the roof. Such a stack should not open into the attic space, as it would likely cause excessive condensation under the roof. Vents should be kept open in winter, with such insulation of pipes and floors as may be needed for protection from cold. It is only on the more moist sites that so much ventilation is needed for occupied houses. When houses are not occupied and not heated during the winter, condensation may occur on all floor members instead of being limited to those near the outside.

In the second way of preventing condensation, if vents are closed in cold weather, watch carefully for moisture on the sills and joist ends, especially at the north side. If sweating occurs, cover the soil under the house with roll roofing. This stops at its source the moisture vapor that causes the sweating, and makes it possible to close most or all of the vents during cold weather without bringing on decay. Smooth-surfaced roofing weighing 55 pounds or more per roll of 108 square feet has been used successfully under many houses; in none so covered has it been found necessary thus far to open any vents in winter. The roofing should be rolled out with a 2-inch lap at the edges, but no cementing is needed (fig. 12). There are other vapor barrier materials that may be used in this way; but the limited experience with these others to date precludes any definite recommendation concerning their use.

Soil cover under basementless houses also decreases the likelihood of moisture condensation in winter in attics and the decay that is likely

Figure 12.—Roll roofing used to cover the soil under a house. Where such a cover is used, it keeps the soil moisture from vaporizing into the air and then condensing on the sills and joists. Moisture condensation on joists is shown in figure 7. Where roll roofing is used, the crawl-space ventilators, or most of them, can be safely closed during the winter.

to follow. For recommended ventilation in attics, see the section on roofs. Excessive condensation of moisture beneath the floor in warmer weather is less common than in cold weather, but may occur in early summer, especially if the floor is insulated. Such condensation occurs when the outside air is warmer than the crawl space, and occasionally causes serious decay. It is worst near the center of the house, instead of near the outside walls as in most winter condensation. In houses where this is found, abundant ventilation should be provided in early summer to warm up the crawl space. It may be necessary to provide some artificial heat.

Where the water supply comes from a well and enters the house pipe system at a temperature as low as 50° F., there may be enough condensation of moisture on concealed pipes in walls and floors to lead to decay. In houses with such a supply system the cold-water pipes should be insulated before they are enclosed. Ventilation cannot fill the need in such cases.

Sanitation

Leave no wood, paper, trash, or stumps under or near the house, either buried or above ground. Termites particularly may spread from such material into the wood of the house.

Termiteproof Foundations

In all but the northernmost States foundation walls or piers should be so built that termites cannot get through.[6] Poured concrete gives surest protection if so well mixed and tamped that no voids are left in it and no cracks develop; reinforcement is desirable. Masonry walls or piers should have all joints well filled with a dense cement mortar. Hollow-block foundations should be capped with solid blocks, or preferably reinforced-concrete caps at least 4 inches thick. The latter is most effective in preventing termite penetration.

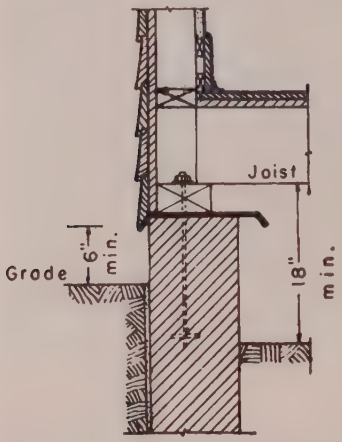

Figure 13.—Metal shield over uncapped unit-masonry wall to protect against termites. Metal shields are effective only if made continuous, with no gaps or loose joints. The hole through which the anchor bolt passes should be sealed with coal-tar pitch.

Termite shields (fig. 13) of corrosion-resisting metal properly installed on the foundations offer an effective safeguard. They may be used when it is desired to take every possible precaution to protect a building from attack, and also provide an added safeguard against some decay infections. They are not generally advised, however, because carelessness in putting them on often defeats their purpose. If the shields cover the top of the foundation wall completely and all joints are sealed or connected with impervious interlocking joints, they make concrete foundation caps unnecessary. Periodic inspections must be made to see that the shields are properly maintained.

HOW TO SAFEGUARD PARTS OF HOUSES EXPOSED TO RAIN

Porches and Steps

As previously stated, overhanging roofs and flashing help to protect woodwork. Some decay is to be expected in porch steps, floors, rail-

[6] Fuller details on termite control are available in U. S. Dept. Agr. Farmers' Bulletin 1911, Preventing Damage to Buildings by Subterranean Termites and Their Control.

ings, or pillars exposed to rain. This, however, can be much delayed. Provide abundant ventilation under porches. Base the lower ends of stair carriages or stringers on bricks, stone, or concrete, well above the ground level.

Where practicable, railings should be so built that the handrail extends over the top of the posts or balusters and keeps them from taking rain water through the ends (fig. 14). Porch floors should slope toward the outside, and frames for screens should have openings through the bottom of the frame to let rain water escape.

Chemical preservative treatment against decay is especially likely to repay its cost for porches and outside steps. When a more thorough preservative treatment is not practicable, the lumber should be immersed after it is cut and fitted on the job, in one of the preservatives that does not interfere with subsequent painting. The wood should be in the preservative at least 3 minutes, and longer if practicable. Such a treatment will have considerable value, provided the wood is dry at the time of treatment and is not put in direct contact with the ground. Where the entire length cannot be immersed, the ends may be dipped and the sides liberally brushed. Such treatment should always come after the lumber is cut and fitted but before it is put in place, so that all ends have the protection. Solutions of pentachlorophenol, 5-percent, and of copper naphthenate containing 2 percent of metallic copper, are among the preservatives that have given good results in dipping tests for service above ground. For wood that is to be painted, mineral spirits or kerosene are good solvents; if not to be painted, a heavier solvent such as diesel or No. 2 fuel oil is better or a water-repellent preservative should be used. Many of the compounds used are highly poisonous; some are flammable. Read caution on page 23 before attempting to use them.

If no preservative is used, or after it is used, it is good practice to apply thick paint or white lead to the ends and edges of floor boards before they are put in place, to hinder the absorption of water or loss of preservative at the joint. Upper surfaces and ends and edges of floor boards and stair treads should be painted, but the lower surfaces should not be painted. Porch pillars should have bases protected against moisture by asphalt or aluminum paint on the lower surface, and be ventilated as shown in figure 15.

Termites also find porches excellent breeding places. In fact, the largest number of infestations occur in enclosed areas such as porches, sun parlors, and terraces where the earth frequently is raised above the outside grade and the termites have little distance to go through crevices in the wall to reach adjoining floor joists.

Much of the hazard of infestation can be eliminated by avoiding the dirt fill beneath concrete floors of porches. In addition, the side walls should be ventilated, and one opening should be large enough to allow

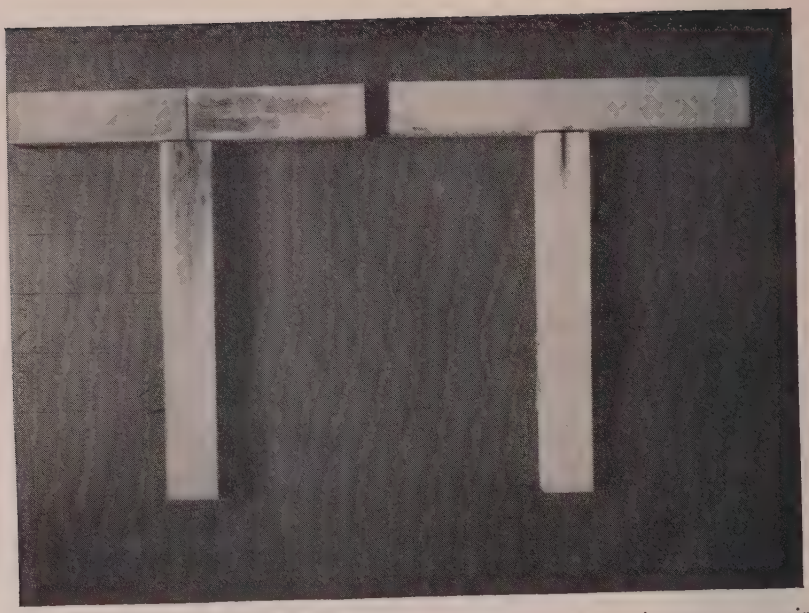

Figure 14.—Southern pine sapwood joints cut open after 3 years' exposure to rain in Mississippi. The joint in the rail over the post at the left has admitted water and allowed decay, while the continuous rail at the right has kept rain out and prevented decay. The discoloration in the post at right is simply iron stain from the nail.

periodic inspection. Further protection can be obtained by poisoning the soil along the wall before the porch slab is poured, using the chemicals and dosages mentioned under the heading "Care of Houses." This is as true of the platform type of porch where the slab is laid directly on the ground as it is for the raised porch floor where a dirt fill may or may not be used.

Windows and Doors

Window sash may discolor or decay, especially in the colder climates where water condenses on the inside of the glass in winter and runs down into the wood. Storm sash is effective in decreasing such condensation. To hinder its absorption by the wood, sash should be primed and back-puttied before glazing (fig. 16). Much of the sash and some of the window frames on the market have been dip-treated with a preservation which increases its resistance to fungi. At least the lower ends of window and door screens, if not treated by the manufacturer, could profitably be soaked a few minutes in one of the solutions suggested for porches and steps, to get the preservative into the joints. Any surfaces newly exposed when fitting should be given one or two heavy brush coats of preservative.

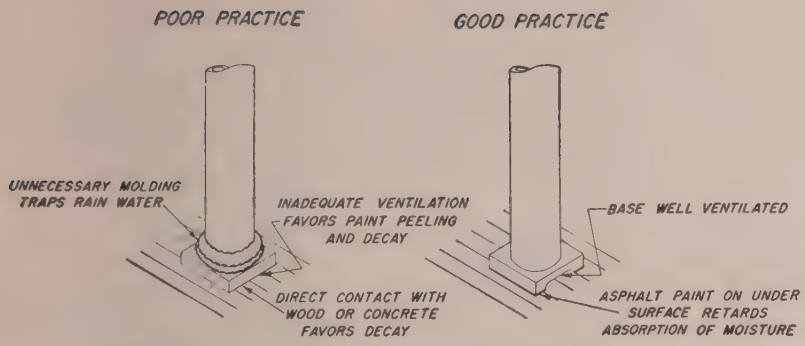
POOR PRACTICE
GOOD PRACTICE
UNNECESSARY MOLDING TRAPS RAIN WATER
INADEQUATE VENTILATION FAVORS PAINT PEELING AND DECAY
DIRECT CONTACT WITH WOOD OR CONCRETE FAVORS DECAY
BASE WELL VENTILATED
ASPHALT PAINT ON UNDER SURFACE RETARDS ABSORPTION OF MOISTURE

Figure 15.—Poor and good practice with porch columns.

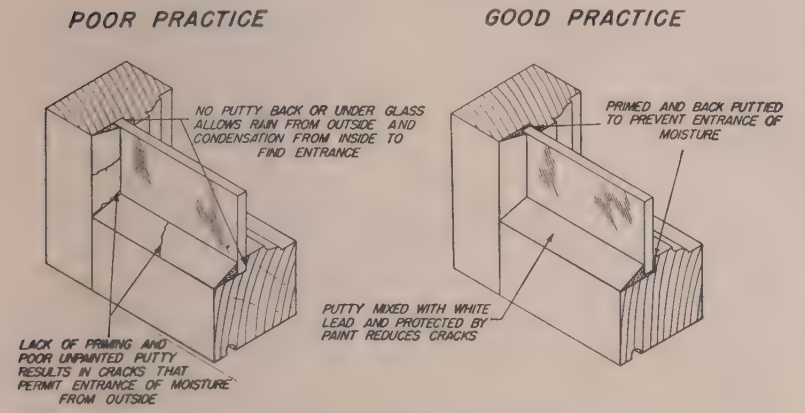
POOR PRACTICE
GOOD PRACTICE
NO PUTTY BACK OR UNDER GLASS ALLOWS RAIN FROM OUTSIDE AND CONDENSATION FROM INSIDE TO FIND ENTRANCE
LACK OF PRIMING AND POOR UNPAINTED PUTTY RESULTS IN CRACKS THAT PERMIT ENTRANCE OF MOISTURE FROM OUTSIDE
PRIMED AND BACK PUTTIED TO PREVENT ENTRANCE OF MOISTURE
PUTTY MIXED WITH WHITE LEAD AND PROTECTED BY PAINT REDUCES CRACKS

Figure 16.—Poor and good practice with window glass.

Garage doors should be built to shed water. Rails, braces, or moldings are best placed on the inner face of the door. If on the outside, they trap water between them and the vertical members. Preservative dipping and painting all contact surfaces in joints, as suggested for porches and steps, are desirable here also. Doorframes should not extend into the concrete. Recommended construction is shown in figure 17. Any glass in the door should be set in putty as in windows, and the wood stops bedded in putty (fig. 16). The overhead or lateral-sliding type of door is less exposed to conditions favoring decay than the outward-swinging type.

Walls

Roofs without overhang or gutters let too much rain water run over the siding. Leaks in cornices, gutters, or downspouts can lead to decay in the wall below them. In well-maintained houses, however, frame walls well above the soil line suffer from decay only when there is some unusual combination of the factors that permit accumulation

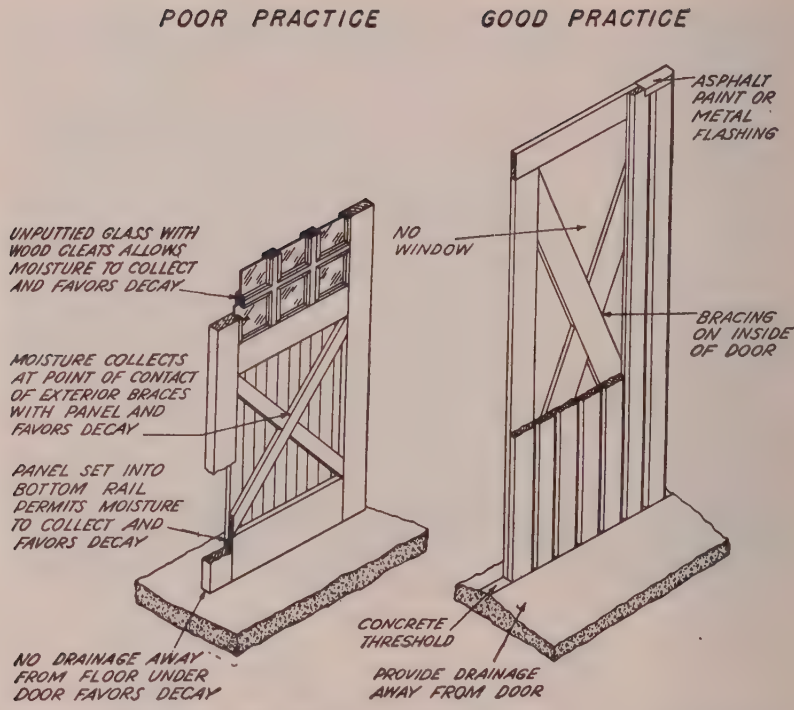
POOR PRACTICE
GOOD PRACTICE
UNPUTTIED GLASS WITH WOOD CLEATS ALLOWS MOISTURE TO COLLECT AND FAVORS DECAY
MOISTURE COLLECTS AT POINT OF CONTACT OF EXTERIOR BRACES WITH PANEL AND FAVORS DECAY
PANEL SET INTO BOTTOM RAIL PERMITS MOISTURE TO COLLECT AND FAVORS DECAY
NO DRAINAGE AWAY FROM FLOOR UNDER DOOR FAVORS DECAY
NO WINDOW
ASPHALT PAINT OR METAL FLASHING
BRACING ON INSIDE OF DOOR
CONCRETE THRESHOLD
PROVIDE DRAINAGE AWAY FROM DOOR

Figure 17.—Poor and good practice in installing garage doors. If window is installed, prime and back-putty before glazing and set cleats in putty mixed with white lead.

of water in the siding or the interior of the wall. Common sources of excessive moisture are green lumber, wet plaster, condensation in the wall during cold weather of water vapor from the interior of the house, rain driven by wind, and excessive running of lawn sprinklers against the house. One of the most important safeguards is to use only dry, unstained lumber.

Flashing of noncorroding metal should be used to keep water out of joints that are otherwise difficult to protect. Ornamental drop siding with rounded or slanting lower edges that lead water into the joints is not so safe as the more usual types shaped so that water drips from the lower edge of each board to the face of the siding board next below. Siding decay is most frequent in ends that are butted against the trim. If the siding ends are under the trim, as is common with drop siding, less moisture gets into the ends and there is less chance for decay.

Some building papers, especially those with a continuous internal layer of asphalt or a shiny asphalt coating, greatly hinder the passage of moisture vapor. In a cold climate such vapor barriers help

to keep the wall dry if put on the inner face of the studding. For sheathing paper outside the studding only "breathing" papers should be used. Most asphalt-saturated but uncoated papers weighing as much as 15 pounds per 100 square feet may be too impervious for sheathing paper. Insulating material having a vapor-barrier surface should be placed in the wall so that the barrier surface is at the inner (warm) face of the wall.[7]

The danger of decay of siding is not considered sufficient to justify the expense of general preservative treatment. In warm, moist climates, however, if sapwood siding is used and butted against the trim it is a desirable safeguard to dip the ends in one of the preservatives mentioned in the section on porches. It is desirable also to give all surfaces of the siding boards near the bottom of the wall a heavy brush or spray treatment with the preservative before painting. Painting the ends of the siding with thick lead is probably a good practice. For greatest safety the lowest board should be 6 inches or more above the outside soil level.

Roofs

Shingles more often deteriorate from weathering and mechanical wear than from decay. Definite roof decay is more likely to occur in sheathing. Rain leaks can lead to decay. Leaks may also occur near the eaves from the water that backs up under melting snow, unless flashing is carried up under the lower shingles. Decay can also occur if there is "sweating"—the condensation on the lower surface of the roof of moisture vapor that comes from below. Such condensation is rare under slate or wood-shingle roofs unless a nonbreathing sheathing paper has been used in the roof. It is common in winter under asphalt roofing, and in cold climates, particularly if there is ceiling or roof insulation without an efficient vapor barrier below it. Both vapor coming through the ceiling from the living quarters and that which finds its way up from moist soil under basementless houses may contribute to this sweating. Soil moisture under the house can be stopped at its source by the soil cover described in the section on Ventilation. Flues for ventilating basements or crawl spaces should never open under the roof. Vapor-barrier paint on walls and ceilings of the living quarters or vapor-barrier paper or foil just above the ceiling are helpful. Attics should be ventilated, with vents at opposite sides and preferably near the peak, with a total unobstructed area of $\frac{1}{300}$ of the ceiling area. The vent area should be multiplied by $1\frac{1}{4}$ if the vents are covered by $\frac{1}{8}$-inch mesh screen, or $2\frac{1}{4}$ if louvers are also added. Flat roofs particularly need protection by vapor barriers properly placed, in addition to ventilation

[7] See footnote 6, page 18.

because it is often difficult to get free air movement under all parts of such roofs.

USING NEW TYPES OF BUILDING MATERIAL

Plywood and the various fiberboards used in recent low-cost construction require in general the same precautions as lumber. Resin glues employed in exterior-grade plywood are themselves fungus-resistant but do not penetrate the wood enough to make it fungus-proof. With either fiberboard or plywood, joint construction should be carefully designed to prevent the entrance of rain water. Edges of exposed plywood should have a heavy coat of thick white-lead paint or other moisture-resistant coating. Horizontal joints or water tables on the outside of walls should be avoided or flashed, since otherwise they often let rain water get in behind them. Exterior grades of plywood should be used not only where there will be exposure to rain but preferably also where it is employed as roof sheathing or over a crawl space beneath a house, since the protein glues commonly used in interior plywood can be disintegrated by molds at a moisture content lower than that needed for the decay of wood.

When heat insulation is used, the likelihood of moisture condensation and consequent decay may be increased. To counteract this, a vapor barrier should be placed between the insulating material and the inside of the house. On the other hand, tight vapor barriers on the outer (cold) surface of the insulation increase the chance for decay.

CARE OF HOUSES

Maintenance

The care of a building frequently requires correcting or compensating for shortcomings in the original construction. If any wood has been left in contact with the ground, it should be removed or the contact should be broken without waiting for signs of decay or termite infestation. But even if the builder's job has been well done in every respect, continued care is needed.

No kind of house will long stand neglect. Leaks in roofs, gutters, or plumbing and the clogging and overflow of gutters, downspouts, or drains can lead to wood decay and termite attack. Repeated overflowing of refrigerator drain pans leads to decay, especially if the water accumulates under linoleum. Cold pipes that "sweat" and moisten adjacent wood for long periods should be insulated. Occupants who close the ventilators under their basementless houses in winter further increase the chance of decay if they fail to open them in early spring. Soil and trash allowed to pile up against the wall, or firewood or lumber stacked in contact with walls or sills, may lead to decay or termite attack.

For proper maintenance any house that has wood members near the ground should be thoroughly inspected once a year, not only outside but also underneath. Except in the northernmost tier of States, a specific search should be made for termite tubes (fig. 3). Careful inspection is particularly needed around close-in porches and boxed-in pipes, where termites are likely to build hidden tubes to the woodwork above. If winged ants or the wings that termites shed suddenly appear in the house, the insects should be examined to determine whether they are termites or true ants (fig. 1). If they are termites, an intensive search should be made for the source of the infestation and their path to the ground should be traced. Tubes or infested wood may be present and serve as a guide. And in all parts of the country, decay or persistent moisture on the wood that may ultimately result in decay should be looked for.

Stopping Termites

If inspection shows termite tubes, these should be destroyed and the nearby soil poisoned. A toxic chemical should be applied in a trench along infested foundation walls and piers.

Materials useful for this purpose are a 10-percent solution of sodium arsenite in water, a mixture of 1 part trichlorobenzene to 3 parts No. 2 fuel or diesel oil, and either a 5 percent solution of DDT or of pentachlorophenol in one of these oils. Coal-tar creosote, 1 part mixed with 2 parts of either of these oils, may be used, but is considerably less effective than the above chemicals.

Sodium arsenite, though valuable, is extremely poisonous and should not be used where it might be hazardous to man and animals. Its chief use is beneath basementless buildings along interior foundation walls and around piers. Care should also be taken in handling the other chemicals as they are either irritating to or are absorbed by the skin. None of these poisons should be used near wells providing drinking water. Nor should they be applied about the roots of shrubs and trees unless the latter are protected from chemical contact. Heavy copper- or aluminum-coated paper is advised to keep the chemicals from reaching the roots.

Because of the fire hazard, great care should be taken to avoid open flames or electric sparks when applying inflammable soil poisons, such as mixtures containing fuel oil, in a confined, poorly ventilated space.

The following procedure may be followed in applying the chemical.

1. Dig a trench the width of a shovel around all piers, continuous walls, and vertical pipes. A trench a few inches deep is ordinarily sufficient where the foundations have shallow footings or where there are no voids or cracks present. A much deeper trench may be necessary along basement foundation walls, especially if they are constructed of unit masonry or have developed cracks. The trench, however, should not extend below the top of the foundation footing. All

cracks in the foundation should be carefully sealed with coal-tar pitch.

2. Where the footing is shallow, pour part of the chemical into the bottom of the trench and the rest on top of the replaced soil. Under buildings with partial excavations and under porches it may be desirable not to refill the trench with the soil.

3. Where the footings are deep, either dig a trench to a depth of about 30 inches or excavate for nearly half the distance and extend crowbar, pipe, auger, or rod holes down the remainder of the way. Such holes should be spaced about 6 to 8 inches apart, depending on the permeability of the soil. After treating the bottom of the trench with part of the chemical, replace about 6 inches of soil and make a second application of the poison. Repeat this process so as to provide an even distribution from the bottom to the top of the trench.

4. In loose sandy soil, bore-holes, made with any one of the tools mentioned above, may be substituted for trenching. The required amount of chemical must be distributed equally among the holes within a treating unit.

5. Dosage applications per 10 linear feet are as follows (shallow footings) : [8]

Sodium arsenite, 10-percent solution in water—2 gallons
Trichlorobenzene and fuel oil (1–3 by volume)—2 gallons
DDT, 5-percent solution in fuel oil—4 gallons
Pentachlorophenol, 5-percent solution in fuel oil—5 gallons
Coal-tar creosote and fuel oil (1–2 by volume)—6 gallons

Stopping Ordinary Decay

If the house has a wood porch or steps, replacements of obviously decayed boards or bases of pillars should be made with the same precautions advised for new construction in the section on porches and steps. Decay in sash or window sills often means that there has been too much condensation of moisture on the inside of the glass; if this sweating cannot be sufficiently decreased by the measures suggested under "Windows and Doors" (p. 18), the sash should be taken out and allowed to stand with the bottom rail submerged in a 5-percent pentachlorophenol solution in mineral spirit or kerosene. Replacement sash should be factory-treated or should be given a short soak in the same preservative before it is installed and painted. Decay in window and door frames often means that more flashing is needed. If there is decay in siding, the recommendations in the section on walls should be followed. If cracks open up where rain water can run into them, occasional use of a calking gun is advised.

If there are unheated spaces under the first floor in which the net area of constantly open vents does not meet the requirements of the section on ventilation (p. 13), the sills and ends of the joists, par-

[8] Dosages are doubled when treating the soil where deep footings are concerned.

ticularly at the north side, should be examined in winter for decay or for visible moisture, which may appear as conspicuous hanging drops as shown in figure 7, or simply as a wet surface. If the floor is insulated and the basement or crawl space is not fully ventilated, there should also be an examination for condensation moisture under the center of the house in June or July. If there is excess moisture either summer or winter that cannot be traced to leaks or direct soil contact, measures for avoiding decay from it can be found under "Ventilation" (p. 13).

Attics, especially insulated attics, if lacking the amount of ventilation advised under "Roofs," should be examined in midwinter for condensation moisture or frost accumulation, and decay, especially at the eaves level at the north side of the house. If paint failures are especially troublesome on the north wall or dark stains develop from moisture seeping out from under the siding, it may mean moisture condensation in the walls which if it persists into the period of warm weather can permit decay. Attic condensation difficulties can be corrected easily by increased ventilation. This, together with the ventilation or soil cover advised for crawl spaces (section on Ventilation) and such vaporproofing as can still be done for the warm faces of the walls, should make the walls reasonably safe.

Stopping "Dry Rot"

Occasionally decay is found to extend many feet from the nearest possible source of moisture. This is likely to mean that it is caused by one of the water-conducting fungi. Between two layers of wood, as floor and subfloor, these fungi commonly produce strands of mycelium thicker and more conspicuous than those shown in figure 4. These fungi are the ones for which the mistaken term "dry rot" is most often used. Ventilation or vapor barriers may limit the spread of these fungi, but cannot be counted on to stop them entirely.

The treatment needed for fungi is in some ways the same as for termites. It is necessary to trace the fungus back to its source of moisture, and cut off the connection. Often it comes up through a brace or frame or wooden concrete form or grade stake that serves as a bridge to let the fungus grow from moist soil to a joist or sill. Sometimes a joist is in direct contact with a tree stump that has been left under the house. In other cases the source from which the fungus is bringing its moisture may not be so easily located. Dirt-filled concrete porches too often have soil in direct contact with the wood sill under the slab (fig. 8, *A*). Or wood embedded in moist concrete may be the important source. These special fungi sometimes get their moisture from the soil without direct wood contact through strands of mycelium that grow for a foot or two over the surface of foundation walls, or through the interstices in loosely built masonry.

If the decay does not stop after all visible connection with infected wood has been blocked, the sills may have to be jacked up enough to allow a noncorroding metal cap to be slipped over the top of the piers or foundation walls, like a termite shield (fig. 13). Another procedure would be to poison the soil at the base of the foundation as is advised for termites (p. 23). Creosote, pentachlorophenol, or arsenate may be used as advised for the termites, or 5 gallons of a 4-percent solution of sodium fluoride may be employed per 10 feet of trench. DDT is not a fungicide and the effect of trichlorobenzene on the fungi is unknown.

Wood used to replace any that is made useless by decay should be dry. If the sources of the moisture that caused the decay infection are entirely eliminated, it is necessary to replace only such wood as is weakened. When there is any doubt as to the moistureproofing, however, and especially if the original infection has spread rapidly, it is safest to remove also the apparently sound wood 2 feet in each direction from the part appreciably decayed, and to make replacements with wood that has been thoroughly impregnated with a preservative (p. 7). Before putting the new wood in place, give all adjacent old wood and masonry surfaces a heavy brush treatment with a preservative such as a 5-percent pentachlorophenol, copper naphthenate containing 2-percent copper, or a solution of 5 ounces of sodium fluoride per gallon of water.

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